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Trauma is the leading cause of morbidity and mortality among young adults all over the world. The kidney is placed high up in the retroperitoneum well protected anteriorly by the peritoneal cushion and abdominal viscera and posteriorly by the tough musculoskeletal structures of the posterior abdominal wall. It still is the most commonly involved viscera in the urogenital tract. Blunt renal trauma is far more common then penetrating injuries (9:1) [1].

Although renal involvement is only seen in about 5% of patients sustaining abdominal trauma[1], it is associated with considerable morbidity and even mortality. Fortunately, a vast majority of patients who have renal injuries are managed conservatively and only less than 10% requires active surgical intervention[2]. As majority of patients are managed conservatively, it is important that they are properly evaluated and the disease staged accurately.

Kidneys with major parenchymal lacerations and with vascular injuries particularly when intra-abdominal injuries are also present are generally managed by surgical reconstruction. Regardless of the mechanism of injuries roughly 90% of explored kidneys can be successfully reconstructed[2]. Adherence to the principles of proximal vascular control, debridement of necrotic tissue, hemostasis, closure of collecting system and coverage of the defect maximize the salvage of renal functions while minimizing potential complications. Proximal vascular control is essentially achieved before all renal explorations. Nephrectomy is required in less than 12% of all cases of renal explorations[3].

Ultrasound, intravenous urogram, CT scans, MRI and arteriography are various imaging modalities used in the radiological evaluation, following a good history and physical examination The decision concerning conservative versus surgical exploration and if exploration is decided whether to go for nephrectomy or reconstruction is based upon proper radiological grading of renal injury. It is; therefore, important to grade renal injury before exploration is contemplated (Figure 1).

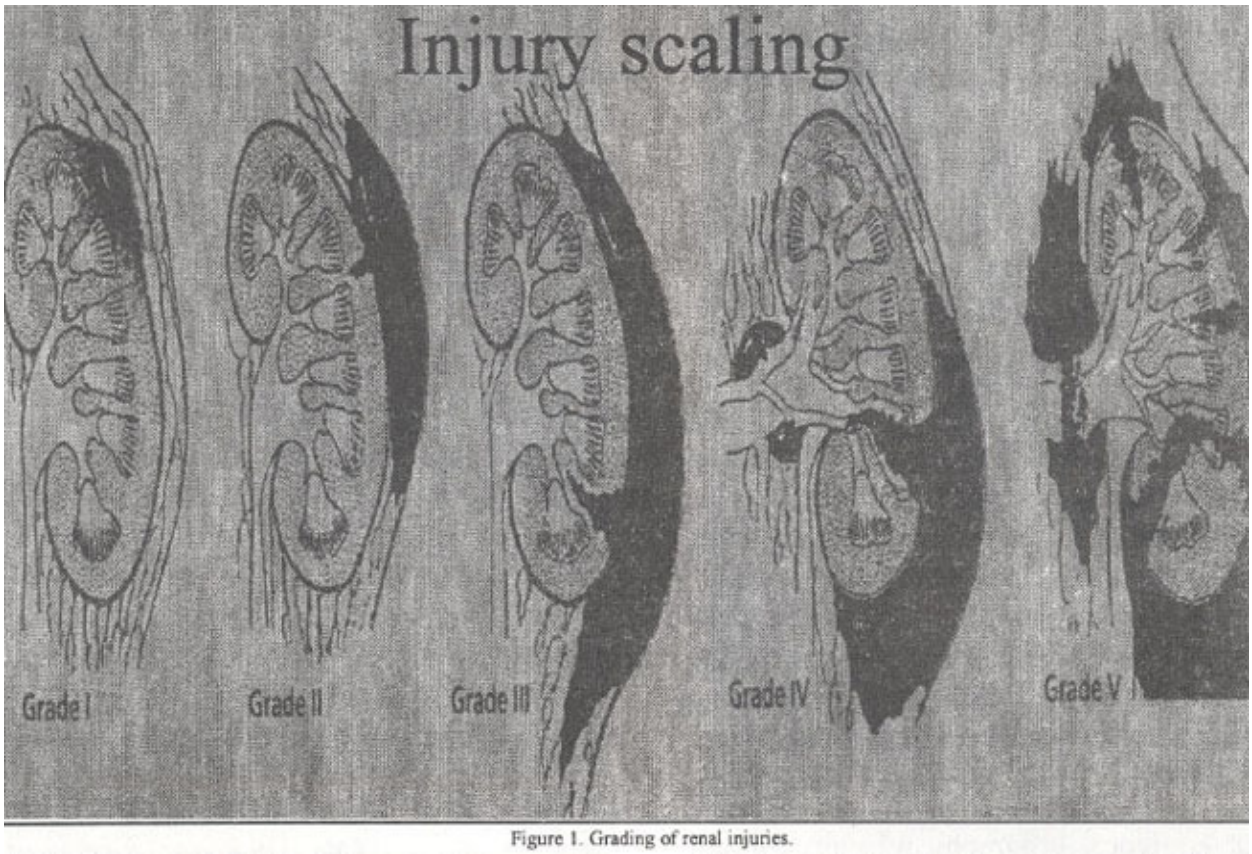

Figure 1. Grading of renal injuries.

This considerably increases the renal salvage.

Indications for Radiological Evaluation

Not all patients of blunt abdominal injuries require radiological evaluation. Indications for imaging include blunt trauma and gross hematuria. Gross hematuria is the most reliable indicator of serious renal injury and is seen in grade HV renal trauma. However, the degree of hematuria does not correlate with degree of renal injury. Grade V renal injuries with renal pedicle avulsion or acute thrombosis of segmental renal arteries can occur in the absence of hematuria.

Patients with blunt injuries and microscopic hematuria who are hemodynamically stable can be managed by close clinical observation without a need for renal imaging but this mandates continuous hemodynamic monitoring and repeated physical examination by the same physician. However, in patients with blunt abdominal injury and microscopic hematuria, hemodynamic instability with a systolic blood pressure of less than 90 mmHg, some form of renal imaging is indicated. All patients with penetrating flank trauma to the back or abdominal trauma or muscle trauma in line with the kidney and associated with gross hematuria, require imaging. All pediatric trauma patients with significant microscopic gross hematuria also need workup. In pediatric age group, kidneys are particularly liable to trauma because they are much larger relative to the body size, are less well protected, the renal fat is usually scant and lower ribs are incomplete. Hemodynamic status is often an unreliable predictor of significant renal injury as children can maintain a normal blood pressure despite extensive blood loss. Patients with blunt trauma, flank ecchymosis, lumbar, vertebral or transverse process fractures, fracture of the lower ribs (11th and 12th) should also be suspected of renal injury.

Ultrasound and Renal Trauma

Ultrasonic evaluation is often the first choice of imaging as it is quick, non-invasive and often

easily available for urgent assessment[4]. As it is true for other anatomic sites, renal ultrasound for acute traumatic injury is greatly operator dependent. Ultrasound evaluation of renal parenchymal injuries is based upon indirect evidence of free fluid in the abdomen. This is, however, present only in 20% of patients with renal injuries and it is more often seen if there is associated bowel, splenic or liver trauma. In well-trained and experienced hands, renal lacerations and hematomas can be reliably identified and delineated. However, ultrasound examination is unable to distinguish fresh blood from extravasated urine, and identify vascular pedicle injuries and segmental infarct5. Identification of urinary extravasation is important, as this often indicates surgical exploration. Pery et al.[6] reported three cases in which sonography using B-mode alone missed major renal parenchymal injuries, later confirmed by CT. However, addition of Duplex sonography improves the identification of vascular injuries. Ultrasonogram of the kidneys is often reported as normal with acute low-grade renal injuries, but is more likely to be abnormal with grade II or greater injuries. These are significant entities, which may indicate active intervention. Although conventional B-mode can miss small parenchymal lacerations, recent report from Germany by Hochmuth et al[7] indicated the potential of newer ultrasound mode (wide-band harmonic) in an experimental animal model in blunt renal trauma. Their results indicated superiority of wide band harmonic over B mode in picking smaller intra parenchymal hematoma.

Intravenous Urography and Renal Trauma

Intravenous urography (IVU) is used for the confirmation of a normal contralateral kidney and assessment of and presence and extent of injury in the traumatized kidney. Although it does not permit accurate staging, in patients who have suffered blunt renal trauma it is reasonable to presume that a normal IVU is indicative of a normal kidney. Minor renal injury including parenchymal injury not affecting the pelvicalyceal system can be missed on IVU; however, intra-pelvicaliceal hemorrhage can be identified as space occupying lesion on a contrast film (Figure 2).

Figure 2. IVU in a patient with blunt abdominal trauma, showing renal hematoma with calyceal distortion.

In penetrating renal injuries, although it is much less sensitive, the likely course of the missile can be ascertained. Radio-opaque markers taped to the skin at the bullet entrance and exit sites help in determining if the kidney was in the missile course. It, however, lacks sensitivity and specificity when it comes to staging parenchymal injuries.

Abnormal or equivocal urography warrants further investigations; in hemodynamically stable patients a CT scan can achieve more accurate staging. The greatest value of urography is for penetrating renal injuries in hemodynamically unstable and blunt renal trauma patients who require immediate surgical exploration. In this situation, emergency single shot urography is required before renal exploration. This consists of 2-mi! kg body weight of standard 60% ionic or non-ionic contrast injected intravenously followed by a single abdominal radiograph ten minutes later. For a satisfactory study, minimum systolic blood pressure of 90 mmHg is required.

CT and Renal Trauma

Computerized tomography (CT) is the study of choice for evaluation of stable adult and pediatric patients with suspected renal trauma. Patients with hematuria of less than 5 red blood cells per high power field, with no history of hypertension and with no pelvic fracture, probably needs no imaging of their urinary tract8. In patients with gross hematuria or any hematuria plus a pelvic fracture or diastasis of the symphysis, computed tomography (CT) is needed to evaluate the kidneys, ureters, and other abdominal structures since there is a strong relationship between renal injury and injury to other organs9. CT provides better information than intra venous urography and arteriography regarding the extent of renal parenchymal injury and hematorna, the status of the collecting system, and the presence of renal vascular injury[10,11]. Renal artery occlusion and

global renal infarct are noted on CT by lack of parenchymal enhancement or a persistent cortical rim sign. Cortical rim sign represents a thin peripheral region of cortical enhancement that is thought to be due to intact subcapsular cortex, perfused by perirenal capsular circulation. Although reliable for demonstrating renal infarct, the down side to using the rim sign is that it is usually not seen until atleast 8 hours after injury[12].

CT images greatly enhances its value in better identifying the extent of injuries (Figure 3, a-d).

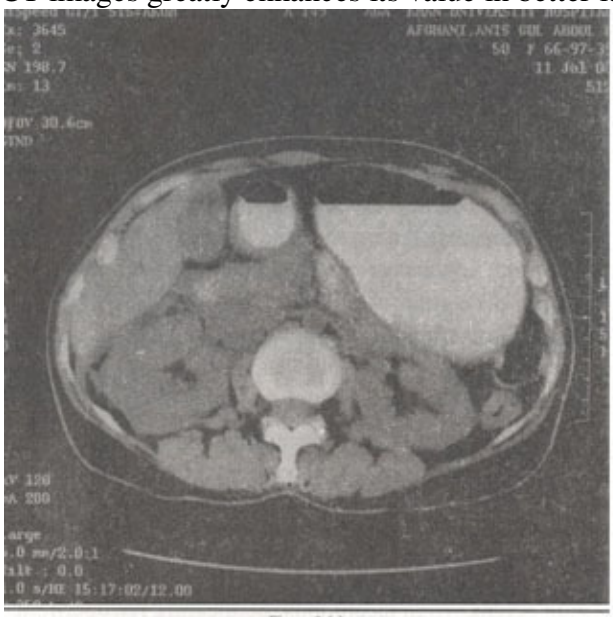

Figure 3 (a).

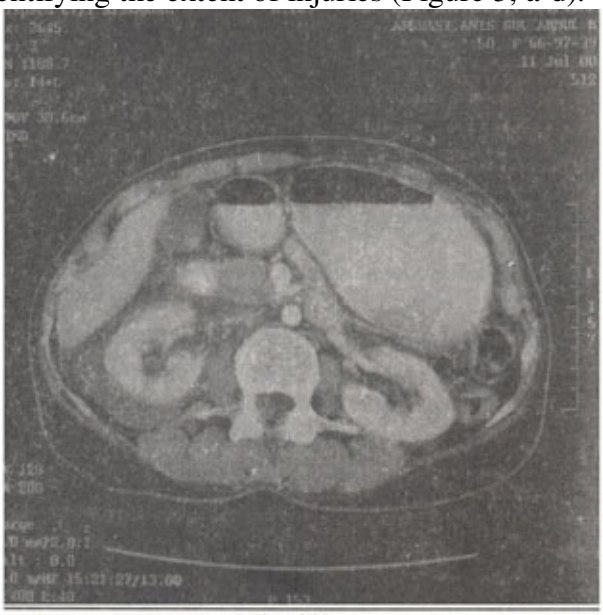

Figure 3 (c).

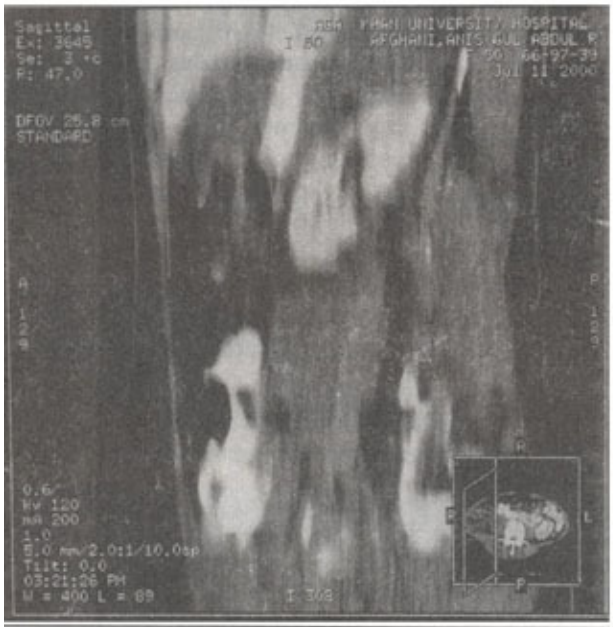

Figure 3 (b).

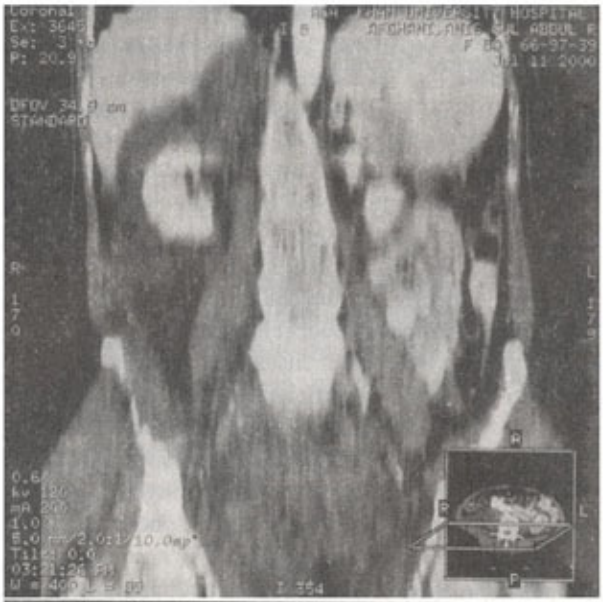

Figure 3. CT in a patient with renal trauma showing peri-renal hematoma and renal parenchymal lacerations, (a) before and (b) after intravenous contrast, (c and d) Sagittal, coronal reconstruction respectively, showing extent of injury extending into pedicle.

In recent years, with the evaluation of fast scanning and image reconstructing helical CT scanners the turn around time for renal trauma imaging is now in the 10 minutes range. Sagittal and coronal reconstruction of spiral Helical CT in the arterial phase (20-30 seconds) is useful to help delineate renal arterial injury. Helical CT in the early cortical phase (40-70 seconds) of the

renal parenchyma may not depict injury. Later imaging in the nephrogram phase (80 seconds or later) for detection of renal parenchymal and venous injury and delayed images (2-10 minutes) for detection of extravasation of urine or CT images extravasated urine can be distinguished from blood in that it accumulates, while extravasated arterial contrast dilutes out after the bolus of contrast is stopped[13,14]. CT, performed within few hours of injury can miss total urétero-pelvic junction disruption. This is better identified by IVU.

Arteriography and Renal Trauma

With the advent of accurate and quick CT imaging the use of arteriography in renal trauma has diminished. However, renal arteriography does provide an opportunity to stage the injury and if necessary to embolize the bleeding points at the same time[10]. In the acute setting, the use of renal arteriography and embolization in cases of renal trauma is very much limited, because it is time-consuming and patients with active bleeding need to undergo immediate exploratory laparotomy. Furthermore, during laparotomy, the kidney can be explored and surgically reconstructed. Arteriography and superselective embolization continue to play an important role in the evaluation and the treatment of posttraumatic arteriovenous fistulas or persistent delayed renal bleeding[11].

MRI and Renal Trauma

Logistical and technical problems like availability of MRI equipment, time-consuming process of performing MRI, and motion artifacts created by the movements of the diaphragm and abdominal wall have limited the use of MRI in assessing blunt renal trauma[16]. However, when compared with CT, MRI has some potential advantages including lack of ionizing radiation and the ability to obtain axial, sagittal, and coronal sections without reformatting[17]. It can also be used in patients with prior history of contrast allergy and pre-existing renal insufficiency. In the radiological evaluation of blunt renal trauma, high field MRI is as effective as CT in detecting and assessing parenchymal lacerations or perirenal hematomas, although MRI can give additional information on the extent of lacerations or the rate of perirenal hemorrhage[18]. The crucial factor in increasing the accuracy of MRI in blunt renal trauma is the use of the dynamic contrast enhancement technique with multiple slice orientation. The possibility of sequentially following the contrast enhancement pattern of the entire kidney, including the fragmented parts, is valuable in assessing the perfusion and viability of the injured tissue. MRI of the kidneys is indicated when the CT findings are equivocal or show a severe (grade 111 -V) renal injury. Sonography though is handy, easily available and a cheaper option in the initial work up of patients with renal injuries but a negative ultrasonogram does not exclude renal injury and depending upon clinical and laboratory findings, other imaging procedures are required. It could be considered as an extension of physical examination and not a definitive tool to exclude renal involvement in cases of acute abdominal trauma. It is also technically difficult to perform ultrasound in cases of acute abdominal trauma because of concomitant fractures, bandages, and presence of ileus, open wounds or in case of moderate-severe obesity. The overall accuracy is variable, time consuming, thus it allows to diagnose the injuries and to identify which patient require more aggressive radiological exploration to obtain a diagnqsis of certainty[5]. It is, however, important that ultrasound examination should not be done in cases of unstable hemodynamic status or if there are associated injuries that contraindicate unnecessary delays. In the decision concerning conservative versus surgical exploration, use of conventional or helical CT is the most important imaging modality used in the evaluation of stable trauma patients with suspected renal injuries. CT imaging has the advantage of both being sensitive and highly specific for demonstration of urinary extravasations, staging perenchymal lacerations,

delineating retroperitoneal hematoma and associated intra-abdominal injuries (spleen, liver, pancreas and bowel). CT has replaced arteriography in the acute evaluation of patient's renal trauma and it reliably delineates segmental parenchymal infarct and segmental and mid arterial injuries. Lack of parenchymal enhancement or persistent cortical rims are reliable indicators of renal artery occlusion and global renal infarcts on a CT scan. However, the limiting factor of using the rim sign is that it does not appear until 8 hours after injury. Advantage of CT scan is that it is available in most trauma centers; it is hon-invasive and can be used to evaluate injuries to other intra-abdominal viscera.

Present indication of angiography is to evaluate and selectively embolize bleeding points in patients with delayed hemorrahage following renal trauma. MRI is employed in patients with renal insufficiency, contrast allergy or in evaluation of a hemodynamically stable patient.

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